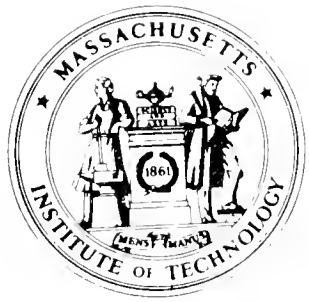

Research Program on the
Management of Science and Technology

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A STUDY OF THE INVENTION AND EXPLOITATION OF IDEAS

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COMMERCIAL INNOVATIONS FROM UNIVERSITY LABORATORIES

A STUDY OF THE INVENTION AND EXPLOITATION OF IDEAS

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Research and development has been a subject of interest to both students of management and practicing managers for many years. Many companies began to recognize the potential of technological innovation in the decades surrounding the Second World War and many organizations established specialized research and development divisions or laboratories. The numbers of people involved in these organizations and the extensive commitment of resources they required generated an expanding audience interested in stimulating industrial innovation.

The discussions of research and development that have resulted have been marked by frequent changes in emphasis and focus. Two of the most important topics discussed have been creativity and entrepreneurship, the first of which was most significant in the earliest discussions of innovation, and the second a subject which has assumed recent significance.

Viewed most simply, laboratories can be regarded as sources of inventions and ideas. One of the first subjects discussed by authors interested in research was therefore naturally the conditions which encourage the application and development of creativity. When research laboratories did not fulfill the optimous expectations that justified their initiation, means for improvement were sought. The result was a wave of interest in creativity, a wave which has been documented in such anthologies as Parnes and Harding (1962), Taylor and Barron (1963), and Taylor(1965).

Unfortunately, focusing on creativity may have reduced attention to the ultimate objective of industrial research -- the commercial introduction of ideas. It is probably true that in the early writings on R & D the assumption was implicitly made that, once presented, an idea could be readily communicated and therefore developed.

As Allen (1966) and Rath, Trueswell and Rubenstein (1966) have shown, however, the flow of information within and between scientific and technical organizations is neither automatic nor strongly facilitated by mechanical means. Particularly within the engineering community, communications are highly dependent on organizational relationships and social factors. The mere existence of an idea does not therefore guarantee it will receive the attention necessary for development.

Because of this difficulty in transferring ideas an interest in technology transfer and entrepreneurship has currently assumed the status once granted to creativity. These factors have been emphasized in the broad survey studies of Myers (1967) and of Project Hindsight (Sherwin and Isenson, 1967), in the management research undertaken by Roberts (1968), as well as by practicing business leaders (Charpie, 1968).

These shifts in emphasis may be due to changes in the recognition of the symptoms of ineffectiveness in research and development organizations rather than to any fundamental changes in the process of innovation. Creativity and technology transfer are <u>both</u> relevant to an understanding of R & D effectiveness. Innovation -- the reduction of new ideas to economic form and their introduction to the market -- involves two very different phases, invention and exploitation (Jewkes, Sawers and Stillerman, 1961; Baker, 1966; Morison, 1966; Marquis and Gruber, 1969).

The research reported in this paper deals with both stages of

innovation. Sixty-six M.I.T. faculty, representatively sampled from three departments, were interviewed. The activities and background of those reporting the invention of potentially commercial ideas were compared with similar data for those reporting no such experience. The ideas described had been developed to varying degrees. These ideas were examined to determine factors which differentiated the more exploitive inventors and the more exploited ideas from their less exploited counterparts.

Background

Research reports are typically inadequate in summarizing the relevant literature; this paper is no exception. The following discussion is a very brief outline of related work.

Two stage models of innovation are useful and necessary because of the distinct environmental influences and personal characteristics associated with inventive and exploitive behavior. The inventor, for instance, is believed to be particularly endowed with "creativity," a personal ability or propensity to deal successfully with novel problems. This is a classical assumption; modern research has primarily been devoted to the development of independent measures of creative ability or to means by which its development can be encouraged (Nichols, 1965). Environmental influences on invention have more recently received attention. The presentation of a basic need or problem has been shown to encourage invention (Nelson, 1959; Baker, Seigman and Rubenstein, 1967). However, the simple presence of a creative person in a demanding environment does not guarantee invention. It is more useful if the environment in which he participates is diverse (Pelz, 1967; Pelz and Andrews, 1966; Peters and Roberts, 1969).

Research scientist and engineers are more productive when they divide their time between work described as research and development rather than concentrating on one to the exclusion of the other (Pelz, 1967). Productivity in these studies was measured by peer ratings as well as by the number of papers and patents.

To summarize, an inventor is quite likely to exhibit a high natural creative ability and be involved in a diverse environment which presents a variety of problems to his attention. These factors do not seem likely, however, to be useful in characterizing the environment or nature which encourages entrepreneurship.

The personal factor that should most closely be associated with entrepreneurship or exploitive behavior is achievement motivation. Achievement motivation can be roughly characterized as task-oriented behavior or persistence in completing tasks when 1) the individual is responsible for his own performance, 2) success or failure is explicitly evaluable, and 3) there is at least some risk concerning the success of the outcome (Atkinson, 1964). These characteristics are not necessarily those of the inventor; they have been shown not to be closely associated with outstanding scientists (McClelland, 1962). A particularly innovative person -- one likely to both invent and subsequently reduce his idea to economic practice -- could be expected, however, to have both the creative capacity of the inventor and the achievement drive of the entrepreneur. Studies by McClelland (1961) and his colleagues have shown TAT-assessed n-achievement to be related to entrepreneurial behavior, and Roberts and Wainer (1967) note that their sample of Boston technical entrepreneurs more frequently than chance expectation have demographic characteristics which McClelland's work show to be related to n-achievement.

Wainer and Rubin (1967) have shown that the business success of 51 of these entrepreneurs was related directly with TAT scores for achievement motivation.

Research Methods

A standarized questionnaire was developed for administration to proportional random samples of M.I.T.'s Mechanical Engineering Department, Electrical Engineering Department, and Physics Department. The samples were stratified by academic rank, ranging from Instructors and Research Associates to Full Professor. Overall, sixty-six respondents cooperated (including three from the Civil Engineering Department which was used for a brief pre-test), of seventy-two potential subjects sampled and contacted. No replacements were selected for the non-respondents, nor was the analysis of the data adjusted to account for them. Those who did not respond were generally not interested in participating in the study either because they did not wish to provide the time for the interview or because they were generally hostile or antipathetic to social research.

The interviews were arranged by phone. The respondent was invited to participate and the study was generally described as covering the "occurrence and interest of M.I.T. faculty in ideas with commercial potential." At this time, as well as in the actual interview, an attempt was made to maintain as much a neutral attitude as possible toward the subject of research. For this reason certain terms, such as "invention" and "exploitation" which seem loaded with value connotations, were avoided in questions directed to the respondents. The interviews themselves were carried out by asking the respondent to respond to one copy of the pre-tested questionnaire

while the author noted his responses on another. The respondents were frequently asked to elaborate on items or to clarify certain responses. Hopefully this procedure contributed to the reliability of the data.

The first part of the questionnaire dealt with the man's educational and family background as well as with the emphasis of his current activities among various kinds of research, teaching and other activities. Those respondents who indicated that they had experience with externally-oriented, commercially exploitable ideas were asked to describe one or two such ideas in detail, describing each and responding to a number of checklist items which indicated perceptions of its economic potential.

In the last two departments in which interviewing took place, Electrical Engineering and Physics, the respondent was invited to take a short version of Mednick's Remote Associates Test (Mednick, 1962), a pencil and paper instrument designed to assess creativity. The specific test used was developed from data on the item validity of the original Mednick instrument. While Mednick's version contains thirty items for which forty minutes are allowed, Hansen (1964) has shown that the ultimate ordering of respondents is substantially unchanged after only fifteen minutes. The author's version used the sixteen most valid of the original thirty items, and allowed ten minutes for each respondent to work on the set of problems. The split-half reliability for the test was estimated to be .73 for the thirty-seven respondents who were given the test.*

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*Using the Spearman-Brown correlation (McNemar, 1962, p. 150). The instrument was later administered to a sample of 42 attendees of the summer course in R & D management at M.I.T. with similar results -- the reliability then was estimated to be .69. Because of the small range of potential and actual scores, and because the splitting into halves of odd scores always contributes to an error of .5 from a perfect linear correlation, the reference of a perfect correlation is slightly different from the customary unit

Because of concern for interviewing time and the fact that the sample was made up of scientists and engineers, individuals customarily hostile and unresponsive to the Thematic Apperception Test, no such instrument was included. The demographic characteristics discovered to characterize technological entrepreneurs by Roberts and Wainer (1967) and shown elsewhere by McClelland (1961) to relate to need for achievement were relied upon as potential surrogate indices for that variable. It will become evident later that this did not yield entirely satisfactory results. It is however questionable whether any of the conventional means for determining achievement motivation could have been successfully administered with sufficient response and reliability within this particular sample.

The respondents were initially advised that the interviews would require an hour. In actual practice the interviews tended more frequently to last an hour and a half. It is fair to say that the majority of the participants expressed considerable interest and occasionally even enjoyment in the interview and in the subject of the study. This is true despite the fact that it is equally fair to say that the initial attitude of most respondents was not overwhelmingly more positive than was that of those who chose to be non-respondents.

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value. An estimate of the potential "perfect" correlation was derived by simulating an exact relationship based on the actual total scores of the respondents. Even scores were split evenly. The unit remainder for odd scores was assigned to one of the halves on an alternating basis. The estimated perfect correlation derived by this procedure was .94 for both samples.

Results -- Invention

It is convenient to present the analysis of the data on invention and exploitation separately. The significant results for the invention of commercial ideas are presented first, in this section, and those that deal with exploitation are summarized in the section which follows.

Those respondents who reported that they had had commercial ideas while at M.I.T. scored significantly higher on the Remote Associates Test (Table I). As the range data shown in Table I imply, however, the Remote

TABLE I

Remote Associates Test Scores and Reporting Ideas

	Mean RAT Scores	Range
Respondents Reporting Ideas	7.77	1 - 13
Respondents Reporting They Never Had Such Ideas	5.73	2 - 10

$N = 37$; $t = 2.02$, $p = .025$

Associates Test results behaved as if there was a threshold, respondents scoring beyond the median were particularly likely to invent. The data also indicate a considerable risk of error to the assumption that low scorers are not likely to invent. Table II, which summarizes the same data used to create Table I, emphasizes these two observations using the a posteriori observation that there was a "break" in the data at the median test score of seven. It is noted that this "threshold" phenomenon with RAT data has also been observed by Gordon (1966).

TABLE II

Remote Associates Test Scores and Reporting Ideas

	Number Having Remote Associates Scores which were	
	Low (< Med = 7)	High (≥ Med = 7)
Respondents Reporting Ideas	1	14
Respondents Reporting They Never Had Such Ideas	10	12

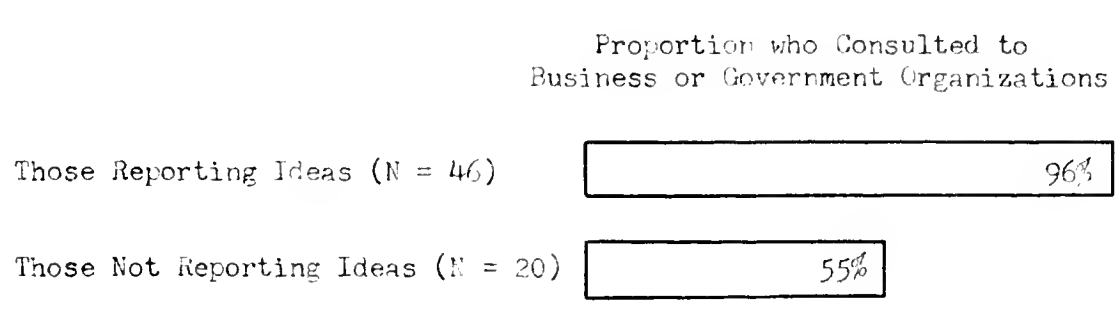
Fisher Exact p = .002

Briefly, those reporting ideas were, as expected, more capable of high RAT scores than their colleagues who reported no experience with commercial ideas. Since it is not too striking to assert that inventors are creative, these data may assume their greatest significance when viewed as a further corroboration of the usefulness of the RAT instrument, with a criterion which differs somewhat from those examined heretofore.

Those reporting ideas were also involved in more diverse work as measured by two independent criteria. As Figure I shows, those reporting ideas were much more likely to spend some time consulting than were those who did not report ideas. A second test measure of diverse work from which the stimulus for ideas might derive was based on that used by Pelz (1968). Diverse technical work was presumed to be that described by the respondent as including both research work and development work. Those involved in non-diverse work were those who reported all of their technical work was either research or development. As Figure II shows, the technical work

FIGURE 1

Inventors Consult



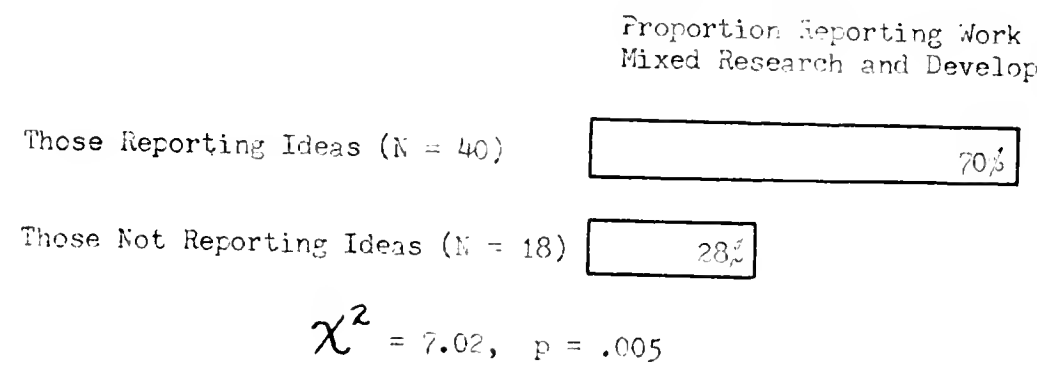
of those who reported ideas, including both academic research and consulting, was more frequently mixed between research and development, while those not reporting ideas more frequently emphasized either research or development to the exclusion of the other.*

Thus, those faculty who had experience with ideas with commercial potential were, as hypothesized, shown to be more frequently involved in a diverse and demanding working environment and gave evidence of high creative ability, as measured by an independent instrument. In fact, there was some slight evidence of interaction between the environmental

*It might be presumed because of the academic sample that this reflects the lack of invention of people in research rather than in development. It is true that only four of the twenty-five who performed non-mixed work performed purely development. However, an explicit test was made of the hypothesis that development was more important to invention than research by testing whether the difference between the proportion of technical work in development less the proportion of time in research was significantly larger for the inventors than for their colleagues. There was no such difference. However, the absolute value of that variable was related to invention ($p = .03$) -- the data simply reaffirming in another way that it is the diversity of work that is important rather than its primary emphasis.

FIGURE II

Inventors Perform Diverse Technical Work



and the personal factors, suggesting that the creative person is particularly likely to actualize this potential within a diverse environment. As Table III shows, there was a significant association between RAT scores and the reporting of commercial ideas only within the portion of the sample that was involved with a particularly diverse working environment.

TABLE III

Interaction Between Invention, RAT Scores and Diverse Environment

	Percentage Reporting Commercial Ideas	
	Those Who Both Consult and Perform Diverse Technical Work	Those Who Either Do Not Consult or Do Not Perform Diverse Technica Work or Do Neither
High RAT (> Med = 7)	100% (N = 10)	50% (N = 4)
Low RAT (≤ Med = 7)	67% (N = 6)	47% (N = 15)
	N = 16 Fisher Exact p = .06	N = 19 Fisher Exact p = .33

It is worth noting that respondents who scored high on the Remote Associates Test were also likely to be involved in technically mixed work ($p = .02$). This suggests the encouraging conclusion that unusually creative people may select for themselves a particularly stimulating environment. However, causation is of course impossible to assess, and it may merely be that participation in such a stimulating environment is one way in which to acquire the kind of skills useful in the Remote Associates Test.

Results -- Exploitation

The data which deal with the exploitation of the sampled ideas were made difficult to analyze by two conditions. In the first place, it is difficult to specify an entirely acceptable criterion by which it is determined that an idea has been "exploited." There are obviously a variety of different things that an individual can do to support an idea. Table IV includes the fifteen different follow-up actions or steps that were observed in this study. Many of these may be more or less natural given the nature of the specific idea or the immediate circumstances of the inventor. Furthermore, the degree to which such different acts appear to be exploitive is apparently strongly related to the values of the beholder. A man particularly committed to his academic career may be reluctant to involve himself with industrial or consulting companies and may limit his pursuit of ideas to actions which are closely related to his academic work. The data were also made complicated to analyze because of the potential for interdependence within the sample. Forty-one respondents described ideas to the interviewer; a total of 68 ideas were provided. Fifty of these were discussed by 25 respondents who each described a pair of ideas; three were presented by one individual who wished to discuss the three related

TABLE IV

Potential Steps of Action in Exploiting an Idea

1. literature search
2. patent search
3. build a working prototype
4. discuss the idea with department head (nominally required of M.I.T. faculty if they wish to devote substantial time to such extra-academic activity)
5. discuss technical dimensions of the idea with colleagues
6. discuss marketing considerations with marketing experts
7. consider forming a new company
8. write a patent application
9. form a company to exploit the idea
10. sell the idea to a new enterprise group on a royalty basis
11. sell the idea to an existing company on a royalty basis
12. arrange for consultee to follow-up idea in his own company
13. implement the idea through government contracts within the university department or in one of its associated laboratories
14. approach outsiders to consider their exploiting the idea
15. academically exploit the idea -- build for own use and disseminate information through the literature

ideas together. The remaining 15 ideas were discussed by their developers either as the single example of a proprietary, potentially exploitable idea, or as the single example they wished to discuss from a set of potentially valuable commercial ideas.

The criterion problem was treated by creating both a "weak" and a "strong" nominal measure of exploitation. The weak index classified as exploitation any action taken to follow-up the idea, as indicated by an affirmative response to the question "Have you attempted to do anything with your idea?" The strong index classified as exploited only those

ideas pursued to the point that a clearly commercially-oriented or entrepreneurial act had taken place. These steps include items eight through twelve from Table IV: patent action, forming a company, transfer on the basis of royalties, or development through a consulting relationship. Thirty-two (47%) of the ideas were not pursued at all; it is against this sample that both the weakly and strongly exploited ideas were compared. Twenty-six (38%) of the ideas were commercially exploited and are thus included in the strongly-exploited subsample. The remaining ten ideas (15%) had received some follow-up attention by their originators but had not been exploited through any commercial or entrepreneurial activity. They are included in the weakly exploited subsample, but are excluded from the analysis when the strongly exploited ideas are considered.

An analysis of the differences between those respondents who discussed more than one idea and those who reported on only one revealed that the effective overweighting of personal data from multiple-idea respondents which results from treating all ideas as statistically independent was not likely a serious problem. The single-idea respondents were somewhat younger ($p = .05$, 2-tail) and more likely to have done something with their idea ($p = .06$, 2-tail). The author believes that relative to the "real" population of all potentially commercial inventions of such faculty, the procedures used in this study are likely to discover relatively "significant" ideas. The double emphasis of multiple-idea respondents in the following analysis is in contradiction rather than support of this potential bias and therefore the obviously false assumption of statistical independence was accepted for purposes of the statistical analysis.

The exploitation hypotheses which involved principles of achievement motivation were somewhat supported by the data. As Figure III shows, the

first-born inventors were more frequently exploitive, but at significance levels that are at the margin of acceptability. It is possible to assume,

FIGURE III

Exploiters are First Born

Proportion of Ideas whose Inventor was First Born

	Weak Index	Strong Index
Exploited Ideas	(N = 36) 69%	(N = 26) 69%
Non-Exploited Ideas	(N = 32) 47%	(N = 32) 47%
	χ^2 = 2.69, p = .05	χ^2 = 2.08, p = .08

however, that first-born sons who are not themselves born first in the family are likely to develop motives not strongly different from sons who are first born (Altus, 1966). As Figure IV shows, if these men with older sisters, but no older brothers, are grouped with their first-born colleagues, the hypothesis that first-born sons are more exploitive is strongly supported.

The data which deal with religious background are less impressive than those for first-borns (Figure V). There was also no relationship between exploitive behavior and father's occupation as there was for Roberts' entrepreneurs. However, sons whose fathers were non-professionally self-employed more frequently claimed serious interest in being in business for themselves (p = .05). It seems quite likely, therefore, that any relationship between entrepreneurship and a family background in which the father was self-employed is due to the son's familiarity with the conditions of

FIGURE IV

Exploiters are First Born Sons

Proportion of Ideas whose Inventor was a First Born Son

	Weak Index	Strong Index
Exploited Ideas	(N = 36) 92%	(N = 26) 96%
Non-Exploited Ideas	(N = 32) 53%	(N = 30) 53%
	χ^2 = 11.01, p < .001	χ^2 = 11.34, p < .001

self-employment rather than from the development of a particular motivational set. The author believes that the lack of familiarity with entrepreneurship of sons with non-entrepreneurial fathers discourages such men from starting their own business because of a relatively greater concern for the unknown consequences.

FIGURE V

Test of the Hypothesis that Exploiters are More Frequently Jewish

Proportion of Ideas whose Inventor had a Jewish Background

	Weak Index	Strong Index
Exploited Ideas	(N = 36) 33%	(N = 26) 38%
Non-Exploited Ideas	(N = 32) 25%	(N = 30) 25%
	χ^2 = .230, p = n.s.	χ^2 = .605, p = n.s.

It is rather obvious that the combined performance of these two presumed surrogate indicators is inadequate to demonstrate an achievement motivational effect on exploitation. A posteriori observation of the consistency of behavior of the more exploitive respondents however argues the conclusion that these research methods may have been inadequate to demonstrate a motivation effect. As shown in Figures VI and VII, the inventors of the exploited ideas had been much more active both in patenting other ideas and in authoring books. These two variables are the most

FIGURE VI

Exploiters had Authored Books

Proportion of Inventors who had Authored Books

	Weak Index	Strong Index
Exploited Ideas	(N = 36) 50%	(N = 26) 46%
Non-Exploited Ideas	(N = 32) 12%	(N = 32) 12%
	χ^2 = 13.60, p = .001	χ^2 = 6.54, p = .009

persistent correlates of exploitation in the sample. The data presented here are not partialled for age; however, these relationships, as well as all the others presented in this paper, remained significant when this precaution was taken.

Books and patents are not the most widely accepted criteria for academic success. They are not expected elements of academic performance as are the performance of research and the publication of research results. Both appear to be the type of activity that could be expected to interest

FIGURE VII

Exploiters had Earlier Patents

Proportion of Inventors who had Earlier Patents

	Weak Index	Strong Index
Exploited Ideas	(N = 36) 31%	(N = 26) 35%
Non-Exploited Ideas	(N = 32) 9%	(N = 32) 9%
	$\chi^2 = 3.45$, p = .03	$\chi^2 = 3.69$, p = .03

the individual endowed with a high level of need for achievement. Whether one accepts that the data on behavior coupled with the earlier data on background are sufficient evidence to substantiate an achievement motivational explanation of exploitation, it is certainly acceptable to conclude that those individuals in this sample who followed-up their ideas were surprisingly consistent in their behavior. There was definitely a pattern of achievement in related areas that distinguished those who most followed-up their ideas.

Those who exploited their ideas reported more frequently that they were aware of potential financial support for the development of new ideas. Interest in this observation may be reduced because of the potential for circular causation -- it seems obvious that those who pursue their ideas will, in the process, become aware of potential financial support. However, as the data in Figure VIII imply, the relationship was most strong for the more weakly exploited ideas. This suggests, but does not prove, that a familiarity with one or more potential financial sources may be effective in inducing the inventor of an idea to give it a serious preliminary screening.

FIGURE VIII

Exploiters were Aware of Potential Financial Support

Proportion of Inventors who were Aware of Potential Financial Support

	Weak Index		Strong Index	
Exploited Ideas	(N = 32)	78%	(N = 22)	73%
Non-Exploited Ideas	(N = 31)	55%	(N = 31)	55%
	χ^2 = 2.86, p = .05		χ^2 = 1.03, p = .15 (n.s.)	

Multivariate Analysis

Hypothesis testing merely identifies an effect between two variables without indicating the practical importance or degree of the association. Furthermore, the observation of several separate, even significant, correlations does not indicate the degree to which one result may be more important than another, or the extent to which all together contribute to a joint explanation of the dependent condition.

A number of stepwise linear regressions were employed to crudely examine the above questions for which hypothesis testing is of limited use.* The fact that a linear model was used in this procedure should not be interpreted to indicate the author's acceptance of such a model on theoretical grounds -- it is merely the most convenient and, since

*The reader who is interested in a general description of such multivariate models is referred to Blalock (1960). A complete mathematical presentation appears in Kendall (1961). The programs used are available from the biomedical analytical group at UCLA (Dixon, 1967).

monotonic relationships are expected, the most "simple" model to employ.

The general conclusions of the multivariate analyses are:

1. The variables hypothesized to be of interest were found to enter the regression equation earlier than did other variables, and they were generally associated as hypothesized with either exploitation or invention but not both. Specifically, when there were no restrictions placed on the entry of thirty-two personal and demographic variables, the first five to enter a regression on invention were: consulting activity, mixed research and development, joint appointment between the department and an M.I.T. laboratory, Jewish background, and familiarity with capital sources. The first five to enter a regression on exploitation were: experience publishing books, experience with earlier patents, smaller family size, extent of consulting experience, and the inclusion of research in the technical work.

The only non-hypothesized variable to appear in the first five in the invention regression was Jewish background. Missing from the earliest entries is the RAT score. The RAT score was closely correlated with religious background in an unexpected fashion. The general conclusion suggested by the order of entry in the stepwise regression is that the diversity factors were more important to invention than were RAT scores.

The variables entered in the exploitation regression are not those emphasized a priori but are in fact a different set from those entered in invention. The a posteriori significance of book authorship and patents has already been discussed. Smaller family size seems consistent with exploitive behavior because the

relatively limited economic responsibility may less restrict risk-taking, and because family size was correlated somewhat with age.

Another index of the basic correctness of the hypothesized separateness of inventive and exploitive behavior can be found by comparing the above regressions in which all entries were allowed with two others in which respectively only variables presumed to be associated with either invention or exploitation were allowed. Five-variable restricted regressions explained only two and four percent less variance than the comparable unrestricted regressions. In both comparisons the first three entries were identical in the restricted and unrestricted analyses.

2. The degree of variance reduced by the models was generally comparable to or perhaps stronger than that observed in similar studies in the social sciences. An r^2 of thirty-six percent occurred for the five-variable restricted invention model with a sample size of sixty-six. An r^2 of sixty-eight percent occurred for the comparable exploitation regression, with a sample size of 41 inventors.

3. A comparison was made of the relative effectiveness of inventor characteristics and perceived idea characteristics in reducing the unexplained variance in exploitation. The exploited ideas were perceived to have a somewhat longer market lifetime, were felt to be more novel, and were perceived to have a larger market than the unexploited ideas. The first five idea characteristics, however, accounted for less than twenty-five percent

reduction in the variance for the sample of sixty-eight ideas. While it is not true that the nature of the idea was not significant in determining its exploitation there was evidence that the following-up of an idea was more a function of the man than of the idea itself.

Summary and Conclusions

The results of this research are consistent with the following generalizations:

1) Innovation must be considered as the sum of at least two separate processes, invention and exploitation. The conditions related to exploitation are quite different from the conditions of invention.
2) A very important factor related to invention is the participation by the potential inventor, in a diverse technical environment.
3) Exploitive behavior seems most able to be predicted by the earlier occurrence of related behavior by the individual.

This research was carried out within a single institution. The results, however, showed consistency across three different academic departments and are generally consistent with the earlier research used to develop the initial hypotheses. This research was from a variety of settings. There is therefore some justification to an attempt to state general implications.

There are a number of such implications which assume importance to

the management of innovation. The most significant of these is the conclusion that an innovative organization should not be constructed or managed to encourage homogeneity. The effective research organization will contain some people who are expected principally to make contributions as inventors and others who are expected to be exploiters -- "product champions", as described by Schon (1967). It should be clear within the organization that both invention and exploitation can identify "heroes," and the management and reward systems must be created which will reinforce the effectiveness of both types of individuals. Systems or points of view that encourage homogeneity must be abolished. Since it is difficult to identify an individual in advance as more appropriately exploitive or inventive, these systems should encourage self-selection.

For the inventors to be most effective the technical environment should be diverse. Individuals should be encouraged to participate in projects and discussions that involve a spectrum of research and development. There should be a marketing influence present with the objective of stimulating invention by identifying customer orientations and needs.

The entrepreneurial-oriented exploiter must be given opportunities to take risks with his own ideas and those of others. This is the most difficult challenge to an innovative organization -- it must be prepared to be disrupted and changed -- it must identify and encourage personal risk-taking, rather than function as an inhibitor of entrepreneurial activity. Efforts must be made to change the management role from sifting through and "shooting down" ideas to one of encouraging the risk taking of exploitive individuals. New values and measures for risk-taking need to be established beyond those -- success and failure -- utilized now.

Finally, the effective innovative organization must devise new links between inventor and exploiter. Means of communicating ideas and of rewarding such communication must be developed. In part this may result if both diversity and personal entrepreneurship are facilitated, for these activities should improve the interest and personal significance of interpersonal communications for both inventor and exploiter. It is likely however that it would be necessary or useful to develop additional ways to encourage the discussion and communication of ideas. This research suggests the existence of individuals reluctant to pursue their ideas even though the apparent quality of these ideas is not consistently less than that of ideas that others would attempt to exploit. Such people might need an especially supportive management and organization if they are to even attempt transfer to another individual or organization.

It is apparent from this research as well as that of Roberts that universities, or at least MIT, could be a source of important commercial ideas. It seems likely that this potential is underutilized. It is tempting to regard universities as 'sinks' of ideas, in which there are employed a population of individuals already possessing ideas which might be available merely for the asking. In this study forty-seven percent of the identified ideas were strictly un-exploited. The proportion was even higher, two-thirds, for the "most-important" ideas of the 269 individuals questioned earlier in the Lincoln and Instrumentation Laboratories (Peters and Roberts, 1969).

The sink concept. though tempting, is unfortunately not particularly useful because it offers no insight with respect to the transfer of ideas from inventor to potential user, nor does it even consider the important fact that the idea requires the identification of that particular user

before its importance can be assumed. The assumption or observation that there exists a number of unutilized ideas in universities is not particularly useful because it is not obvious how the interested commercial organization can take advantage of or even learn about those ideas in which it might have interest.

It is possible, however, to infer an alternate view which offers more potential. From this study it is apparent that industry can derive benefit from university relationships through the transfer of ideas. To be effective, the relationship must be established so that the resources of the individual faculty members involved can be effectively related to the problems of the commercial company. In effect, to utilize university resources, an industrial company must attempt some connection between the social system of the university and that of the company itself.

Long-range consulting relationships seem ideal means to arrive at the necessary association. It has been observed that short-range, problem-solving oriented consulting relationships are not particularly effective (Allen, 1966). The conditions of a long-range association can be, however, congruent with the conditions of invention identified in this paper. Consulting relationships can be used to force need identification and can be designed to involve the apparently important conditions of diversity.

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